Microgravity 101
(or Why Things In Space Seem to Float)

Most of us have seen pictures or video of astronauts on a spacecraft in orbit around the Earth. The people move around quite easily, their feet not on the floor, and ordinary objects seem to float around the spacecraft if not tied down.

If asked why these things are possible, most people say it is because there is no gravity in space. **<u>This is not true</u>**!! There *is* gravity in space, and certainly in Earth orbit.

In fact, at an altitude of 200 miles above the Earth, where the Space Shuttle and the International Space Station fly, there is still about 91% of the gravity we have here on the ground. That means if you weigh 100 pounds on Earth, you'd weigh 91 pounds on one of those spacecraft . . . that is, <u>*if*</u> you could weigh yourself.

Are you confused now because you have always heard that a spacecraft has zero gravity and that people and things are weightless in space? Well, don't feel bad because lots of people think the same thing. But if you keep reading you will find out what *really* happens in space.

First, let's make sure everyone knows what gravity is.

Gravity is a natural force found throughout the universe. Every bit of matter in the universe has this property called *gravity,* which attracts all other matter in the universe. For example, Earth's gravity is constantly pulling every other bit of matter in the universe toward its center. The strength of our planet's gravitational attraction, or pull, on another body is determined by Earth's mass, the mass of the other body, and the distance that separates them. Gravity also is an *acceleration force*, meaning that the closer the object gets to Earth the stronger gravity becomes and the faster that Earth's gravity pulls the object in. At the Earth's surface, the rate of acceleration is 32 feet per second *per second* toward the planet's core. The "*per second per second"* means the object's rate of acceleration increases the velocity by 32 feet per second each second. We refer to this rate of gravitational acceleration at the Earth's surface, as one *g*.

Now turn this around and go the opposite direction, away from Earth, and it means the attractive force of Earth's gravity weakens as we get farther away, but the ***effect*** of Earth's gravity still extends far out into space. In fact, Earth's gravity even affects the moon and influences its orbit. So, there ***is*** gravity in space and there is certainly gravity on a spacecraft in orbit around the planet!

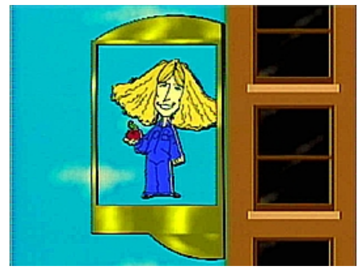
But then why do things on a spacecraft look like they are floating around if there is gravity that should be holding them down? This is where we introduce you to the concept of *microgravity*, which is the environment that is found on a spacecraft in orbit.

Let's examine the word to learn what it means. *Micro* is the scientific prefix that means one-one millionth (or 10^{-6}). We also use *micro* to describe something that is very, very small. So, *microgravity* literally means that the pull of gravity is one-one millionth (or 10^{-6}) of what it is at the Earth's surface. But it can also be used to mean that the pull of gravity is very, very small.

To get true microgravity you would have to travel out into space *17 times farther than the distance between the Earth and the moon!* You would have to be that far away before the pull of Earth's gravity diminished to one-one millionth (or 10^{-6}) of what it is on the surface. But we can create what *appears* to be microgravity with free fall.

Imagine you are in an elevator traveling to the top of a tall building.

Just before the elevator car gets to the top the cable snaps and the car begins to fall.

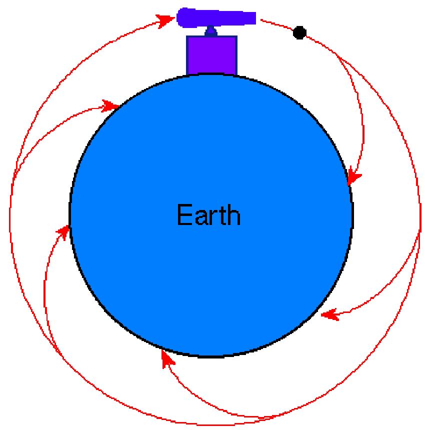


Very soon, the elevator car, you, and everything in it are accelerating toward the ground at the same rate. As everything falls together, they appear to float side-by-side.

Unfortunately, the sudden approach of the ground will soon end your freefall, but imagine how it would be if everything could just continue to fall without hitting bottom.

This is what happens on a spacecraft in orbit around a planet like Earth. This makes more sense if you understand how a spacecraft is able to orbit. So, hold on to that picture of the elevator and read on.

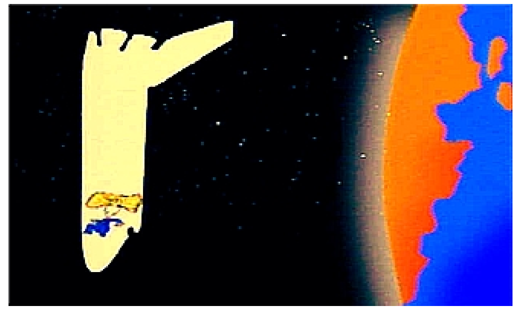
A few hundred years ago, Sir Isaac Newton imagined that an object could be made to travel around the Earth in an endless circle, or orbit. Newton imagined a mountain so tall that it extended above the atmosphere where air friction would be minimal. On top of this tall mountain, Newton imagined a cannon. In his mind, Newton envisioned firing the cannon parallel to the Earth's surface.



In this scenario, two forces would be at work on the cannonball. First, the velocity at which the cannonball were fired would propel it out of the cannon's barrel in a straight line. Second, the force of gravity would cause the cannonball to fall back to the ground. Each time Newton fired his imaginary cannon he used a little more powder, causing the cannonball to travel a little farther before arcing back to the surface because of the pull of gravity. Finally, Newton imagined his cannon firing with enough power that the cannon ball disappears over the horizon. This led Newton to believe that if the cannon were fired with enough power it could travel completely around the Earth and arrive back at the mountain. If this could be accomplished, and provided that no other force but gravity acted upon the cannonball, then it could fall around the Earth indefinitely.

Although we do not fire our spacecraft from a cannon on top of a tall mountain, this is still the principle that allows a spacecraft to achieve orbit around the Earth.

Once the spacecraft reaches a velocity of approximately 17, 500 miles per hour, Earth's gravity still pulls it toward the planet's center, but the spacecraft's velocity, or speed, causes it instead to "fall" off the edge of the planet, just like Newton's imaginary cannonball. So, in essence, a spacecraft in orbit is actually falling *around* the Earth in an endless freefall.



Now if you take the elevator example and move it to the Space Shuttle or the International Space Station you should be able to understand how things *appear* to float in space when they are actually falling. It is because the effect of gravity appears to be very, very small because everything is falling around the planet together, just like on the elevator.

So the moral of this story is this:

A. There ***is*** gravity on a spacecraft in orbit around the Earth. Gravity is what combines with the spacecraft's velocity, or speed, to keep it in orbit. But if the spacecraft could stop, gravity would cause it to fall back to Earth. What's more, gravity is what allows a spacecraft like the Space Shuttle to get back home to Earth! It merely slows down and the Earth's gravity takes over.

B. The environment on a spacecraft in orbit around the Earth ***is not*** zero gravity; it is a *microgravity* environment in which the pull of gravity *seems* small compared to what we experience on the surface of the Earth. This *apparent* microgravity environment is created as the spacecraft and all the people and things inside it fall freely *around* the planet. People and things on the spacecraft only *seem* like they are floating; they are actually falling.

And finally, those of you wondering how *weightlessness* fits into all of this should consider the following: weight is merely a value used to measure the force with which gravity pulls your particular body mass toward the center of the Earth. Weight is mass times gravity. You still have mass *and* gravity, so, you have weight. But you cannot measure weight the ordinary way in space. So things in orbit are weightless because a scale cannot measure anything when it and what it is trying to weigh are both falling around the planet together! In orbit, people and objects may not have weight, but they still have mass and *that's* what you'd have to measure!